The Need for a Durability Index Framework for Electrical and Electronic Equipment to Support a Circular Economy

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Enabling a circular economy aims to reduce the amount of global waste generated from electrical and electronic equipment, mitigate the associated risk to the ecosystem and human health, and address concerns over limited material resources. Durability is a critical concern because keeping products in use for a longer time should reduce resource consumption and waste. Assessing the durability of products and sharing these assessments with the public form a strategy that not only encourages and enables consumers to purchase more durable products but also gives manufacturers an incentive to compete and improve the durability of their products. Although there are some recent initiatives for indexing product durability, there is not yet a standard method for measuring and indexing durability. This extended abstract discusses how indexing product durability can support the shift to a circular economy and overviews the most relevant efforts regarding measuring and indexing durability and relevant product attributes.

Keywords: durability, circular economy, reliability, repairability, sustainability

E-waste, which contains toxic and hazardous material that can adversely affect human health and the environment, has been identified as a fast-growing waste stream. In 2019, 53.6 million tons of e-waste were generated globally, and it is estimated that it will reach around 74.7 million tons by 2030 (Forti, et al. 2020).

Transitioning to a circular economy is a mitigation strategy to minimize the generated e-waste. A circular economy tries to create a closed-loop product life cycle and keep materials in use as long as possible through recycling, reusing, remanufacturing, and improving durability. Improving product durability supports the circular economy by extending product lifetimes and reducing the number of products that are discarded. This should generate less waste, reduce the production of replacements, and reduce resource consumption.

Defining a practical framework for indexing product durability and sharing the calculated indices with the public may improve the durability of products, which consequently helps a circular economy. The durability improvement happens in two ways. First, a durability index guides consumers to purchase more durable products. Lower demand for less durable products causes manufacturers to stop producing them. Second, it is an incentive for manufacturers to compete by producing more durable products.

There have been some related initiatives for quantifying and indexing durability. For example, in 2020, "EN 45552-General method for the assessment of the durability of energy-related products" was published in response to a European Commission request. France implemented a repairability indexing requirement for five electrical and electronic equipment (EEE) categories, including smartphones, laptops, TVs,

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front-loading washing machines, and electric lawnmowers in 2021. In November 2022, four more product categories, including dishwashers, top-loading washing machines, vacuum cleaners, and high-pressure cleaners were added to the list. They plan to introduce a durability index framework by adding more criteria to the current repairability index by 2024.

Although no practical durability indexing method has been introduced so far, we expect that a robust and unbiased durability measure will include a range of relevant product attributes such as reliability, robustness, repairability, upgradability, longevity, and operating time (French Agency for Environment and Energy Management 2021).

Among all the related attributes, reliability and repairability have been widely considered in the previous studies, and these attributes have the most significant impact on product durability (Cordella, et al. 2021, European Committee for Standardization CEN/CENELEC 2020). Although reliability is a well-established knowledge domain, repairability has been more considered in recent years.

Reliability is the probability that a product will perform its intended function adequately for a specified time under specified use conditions. This probability is an index for reliability. Manufacturers assess the reliability of their products using laboratory tests (e.g., accelerated life testing) and field data (e.g., returned devices data). Organizations such as IEEE, IEC, and JEDEC have developed standards and handbooks that provide guidance for measuring product reliability. In addition, many research papers assess the reliability of EEE using more advanced methods such as Bayesian analysis.

Repairability is the ease of returning a product to its functioning state after a failure. The French repairability index, EN 45554, the Joint Research Center repair scoring system, the Assessment Matrix for ease of Repair, ONR 192102, and iFixit are prominent repairability assessment methods, most of which were developed after 2018. These methods commonly calculate a repairability measure by scoring some repair-related parameters (such as the number of steps for disassembling critical parts or the duration of availability of spare parts) and then aggregating these scores into an overall repairability score.

Calculating and combining reliability and repairability measures might yield a durability measure that promotes a circular economy. A circular economy is also a means to the more sustainable use of the earth's limited resources. Therefore, the question of how improving product durability impacts the circular economy can be answered by integrating the durability measures with a sustainability index. Assessing durability and sustainability together has been considered in some ecolabels (e.g., TCO), not for indexing purposes. However, there are previous studies on indexing product sustainability (Hapuwatte and Jawahir 2021) that can be integrated with the reliability and repairability measures.

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